EXHIBIT 1

(3) Two or More Explosionproof Enclosures. Where two or more explosionproof enclosures for which conduit seals are required under 501.5(A)(1) are connected by nipples or by runs of conduit not more than 900 mm (36 in.) long, a single conduit seal in each such nipple connection or run of conduit shall be considered sufficient if located not more than 450 mm (18 in.) from either enclosure.

An example of 501.5(A) requirements for the location of conduit seals in Class I, Division 1 locations is illustrated in Exhibit 501.6. In the example shown in Exhibit 501.6, two seals are required so that the run of conduit between Enclosure No. 1 and Enclosure No. 2 is sealed.

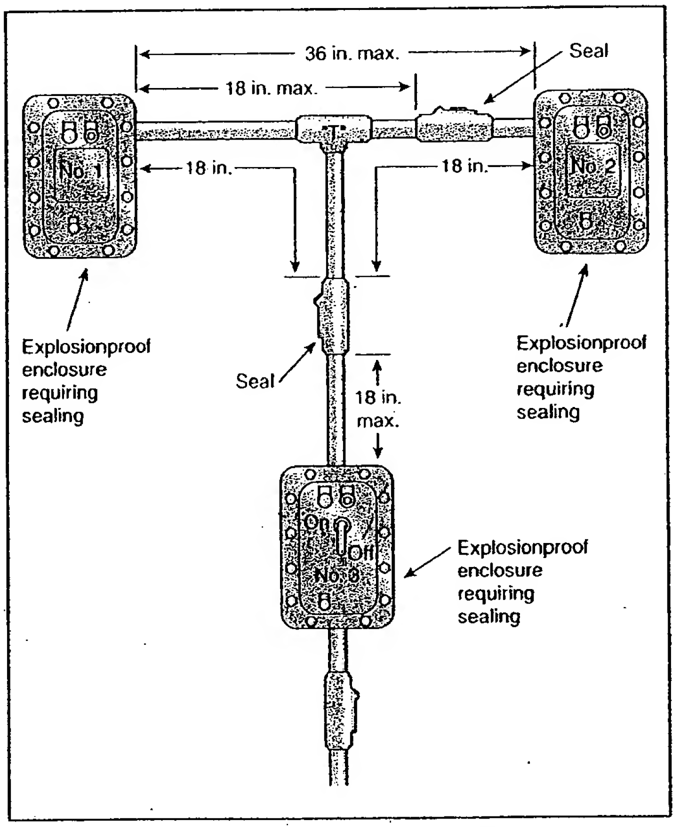

Exhibit 501.6 Two seals are required so that the run of conduit between Enclosure No. 1 and Enclosure No. 2 is sealed. Even if Enclosure No. 3 were not required to be sealed, the vertical seal in the vertical run of conduit to Enclosure No. 3 would be required to be sealed within 18 in. of Enclosure No. 1, because the vertical conduit run to the "T" fitting is a conduit run to Enclosure No. 1.

(4) Class I, Division 1 Boundary. In each conduit run leaving a Class I, Division 1 location. The sealing fitting shall be permitted on either side of the boundary of such location within 3.05 m (10 ft) of the boundary and shall be designed and installed so as to minimize the amount of gas or vapor within the Division 1 portion of the conduit from being communicated to the conduit beyond the seal. Except for listed explosionproof reducers at the conduit seal, there shall be no union, coupling, box, or fitting between the conduit seal and the point at which the conduit leaves the Division 1 location.

Exception No. 1: Metal conduit that contains no unions, couplings, boxes, or fittings and passes completely through a Class I, Division 1 location with no fittings less than 300 mm (12 in.) beyond each boundary shall not require a conduit seal if the termination points of the unbroken conduit are in unclassified locations.

Exception No. 2: For underground conduit installed in accordance with 300.5 where the boundary is beneath the ground, the sealing fitting shall be permitted to be installed after the conduit leaves the ground, but there shall be no union, coupling, box, or fitting, other than listed explosionproof reducers at the sealing fitting, in the conduit between the sealing fitting and the point at which the conduit leaves the ground.

(B) Conduit Seals, Class I, Division 2. In Class I, Division 2 locations, conduit seals shall be located in accordance with 501.5(B)(1) and (B)(2).

(1) Entering Enclosures. For connections to enclosures that are required to be explosionproof, a conduit seal shall be provided in accordance with 501.5(A)(1)(1) and (A)(3). All portions of the conduit run or nipple between the seal and such enclosure shall comply with 501.4(A).

(2) Class I, Division 2 Boundary. In each conduit run passing from a Class I, Division 2 location into an unclassified location. The sealing fitting shall be permitted on either side of the boundary of such location within 3.05 m (10 ft) of the boundary and shall be designed and installed so as to minimize the amount of gas or vapor within the Division 2 portion of the conduit from being communicated to the conduit beyond the seal. Rigid metal conduit or threaded steel intermediate metal conduit shall be used between the sealing fitting and the point at which the conduit leaves the Division 2 location, and a threaded connection shall be used at the sealing fitting. Except for listed explosionproof reducers at the conduit seal, there shall be no union, coupling, box, or fitting between the conduit seal and the point at which the conduit leaves the Division 2 location.

Exception No. 1: Metal conduit that contains no unions, couplings, boxes, or fittings and passes completely through a Class I, Division 2 location with no fittings less than 300 mm (12 in.) beyond each boundary shall not be required to be sealed if the termination points of the unbroken conduit are in unclassified locations.

installation of drain, breather, or combination fittings to guard against water accumulation, which can cause future insulation failures, even though prevalent conditions may not indicate a need.

Exhibit 501.12 illustrates a Class I, Division 1 location using threaded rigid metal conduit or threaded intermediate metal conduit and explosionproof fittings and equipment, including motors, motor controllers, push-button stations, lighting outlets, and junction boxes. The enclosures for the disconnecting means and motor controller for the motor (right portion of the drawing) are placed in a nonhazardous location and are thus not required to be explosionproof.

In Exhibit 501.12, each of the three conduits is sealed on the nonhazardous side before passing into the hazardous (classified) location. The pigtail leads of both motors are factory sealed at the motor-terminal housing, and, unless the size of the flexible fitting entering the motor-terminal housing is trade size 2 or larger, no other seals are needed at this point. Because the push-button control station and the motor controller and disconnect (left portion of the drawing) are considered arc-producing devices, conduits are sealed within 18 in. of the entrance to these enclosures. Seals are required even though the contacts may be immersed in oil.

In Exhibit 501.12, a seal is provided within 18 in. of the switch controlling the lighting. The design of the luminaire, as required by ANSI/UL 844, is such that the explosionproof chamber for the wiring must be separated or sealed from the lamp compartment; hence, a separate seal is not required adjacent to luminaires that comply with ANSI/UL 844. The luminaire is suspended on a conduit stem threaded into the cover of an explosionproof ceiling box. See 501.9 for luminaire requirements.

501.6 Switches, Circuit Breakers, Motor Controllers, and Fuses.

(A) Class I, Division 1. In Class I, Division 1 locations, switches, circuit breakers, motor controllers, and fuses, including pushbuttons, relays, and similar devices, shall be provided with enclosures, and the enclosure in each case, together with the enclosed apparatus, shall be identified as a complete assembly for use in Class I locations.

(B) Class I, Division 2. Switches, circuit breakers, motor controllers, and fuses in Class I, Division 2 locations shall comply with 501.6(B)(1) through (B)(4).

(1) Type Required. Circuit breakers, motor controllers, and switches intended to interrupt current in the normal performance of the function for which they are installed shall be provided with enclosures identified for Class I, Division 1 locations in accordance with 501.3(A), unless general-purpose enclosures are provided and any of the following apply:

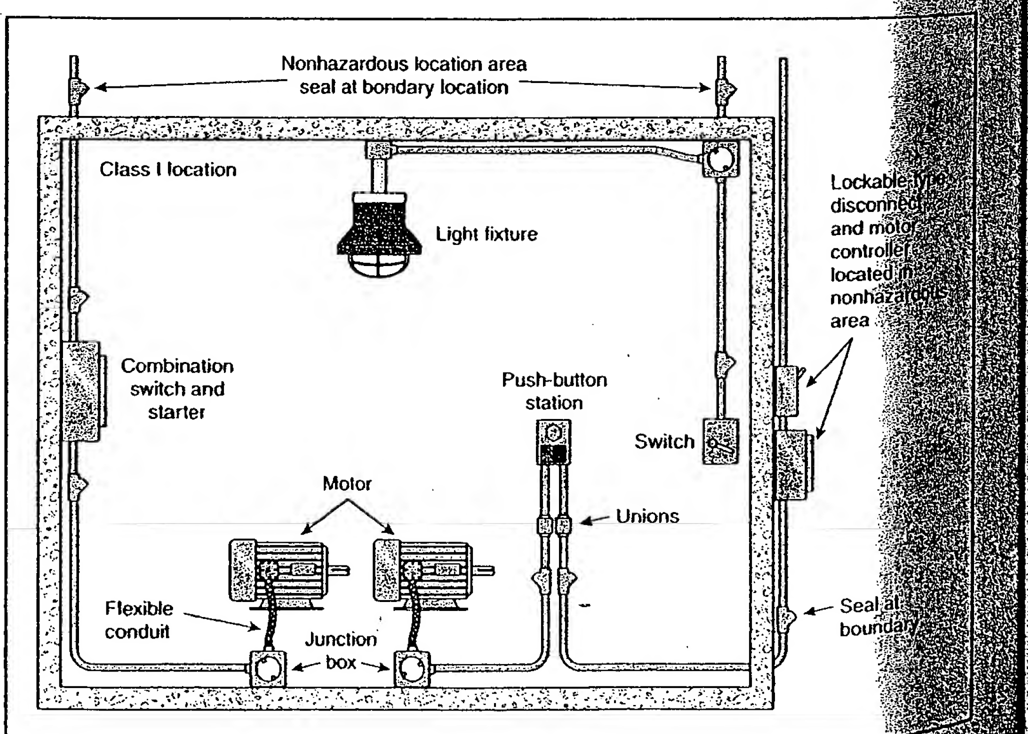

Exhibit 501.12 A Class I, Division 1 location where threaded metal conduits, sealing fittings, explosionproof fittings, and equipment for power and lights are used.

EXHIBIT 2

FIELD LINING SYSTEMS, INC.

Fabricators & Installers of Quality Lining Systems

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COILED DUCT PIPE
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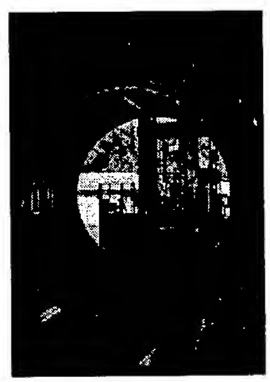
Made from PE 3408 high density polyethylene (HDPE), Quail Coiled Duct Pip designed for long term, trouble free protection of telecommunication, fiber-op and electrical distribution lines. Due to the inherent strength and flexible natur Quail Coiled Duct, a variety of installation methods can be used, with no risk to structural integrity of the pipe. This includes direct burial, plow-in, direction boring or slip-lining through existing pipelines.



Quail Coiled Duct Pipe:

- **Leak proof, heat fused joints duct protects wires and cables from**
- **High strength HDPE withstands external loads**
- **Resists abrasive materials and corrosive chemicals**
- **Long coil lengths reduce the amount of joints and lower installati**
- **Only PPI rated HDPE resin is used (refer to PPI TR 4)**

- **Meets NEMA TC7**
- **Can produce in diameters ranging from 1" - 12", in any color or str**

CORRUGATED PIPE PAGE	**SMOOTH/GAS PIPE PAGE**
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Field Lining Systems does not install Coiled Duct Pipe.
You will need a General Contractor in your area.

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EXHIBIT 3

US005394502A

United States Patent [19]

Caron

[11] Patent Number: 5,394,502

[45] Date of Patent: Feb. 28, 1995

[54] **FIBER OPTIC CABLE HARNESS BREAK-OUT FITTING**

[75] Inventor: **Ronald J. Caron**, Newtown, Conn.

[73] Assignee: **United Technologies Corporation**, Hartford, Conn.

[21] Appl. No.: **171,073**

[22] Filed: **Dec. 21, 1993**

[51] **Int. Cl.**[6] **G02B 6/44**; H02G 3/02

[52] **U.S. Cl.** .... **385/134**; 385/100; 385/136; 385/137; 385/147; 174/72 R; 174/72 A

[58] **Field of Search** .... 385/44, 66, 84, 100, 385/104, 109, 114, 115, 134, 135, 136, 137, 139, 147; 174/70 R, 71 R, 72 R, 72 A

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Primary Examiner—Brian Healy
Attorney, Agent, or Firm—Michael Grillo

[57] **ABSTRACT**

A fiber optic cable harness break-out fitting (**10**) is provided with a pair of support legs (**12, 14**) for supporting contact with a fiber optic cable harness (**42**) having a plurality of fiber optic cables (**45**). A take-off tube (**20**) is positioned between the support legs (**12, 14**), and the fitting is positioned on the harness such that fiber optic cables (**47**) which break-out from the fiber optic cable harness are received through a throat (**22**) of the take-off tube (**20**). Support surfaces (**37,39**) are provided between each of the legs (**12,14**) and the take-off tube (**20**), the surfaces having a controlled radius to control the degree of bend in the break-out fibers (**47**). The legs (**12,14**) are mounted on the harness (**42**) using tie down material (**53**), and the end of the take-off tube is slotted (**24**) such that the break-out fibers exiting the tube are secured within the tube with tie down material (**53**), the slots providing the necessary flexibility to allow the take-off tube end to securely grip the break-out fibers. The fitting may be provided in two halves (**60,62**) for installation in pre-existing fiber optic cable systems and for easy installation in new fiber optic cable systems.

12 Claims, 2 Drawing Sheets

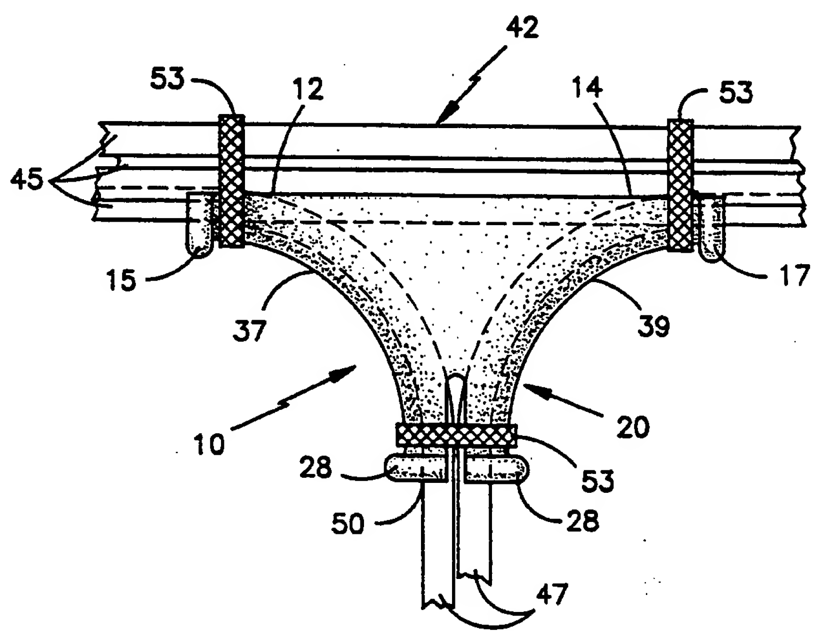
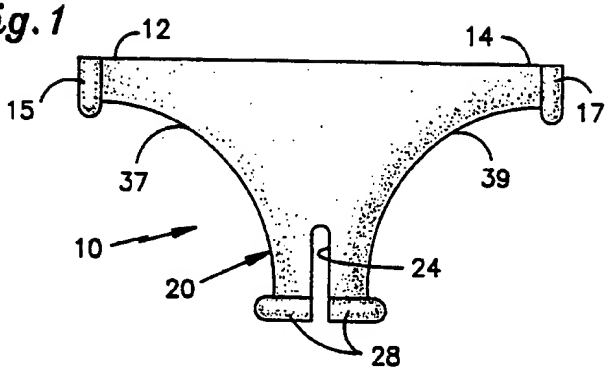


fig. 1



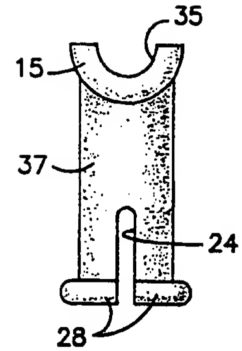
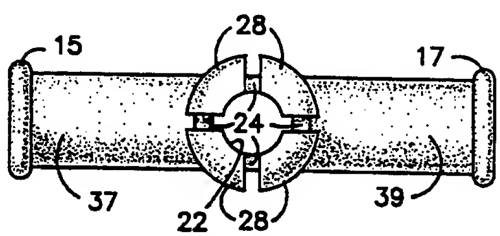


fig. 2

fig. 3



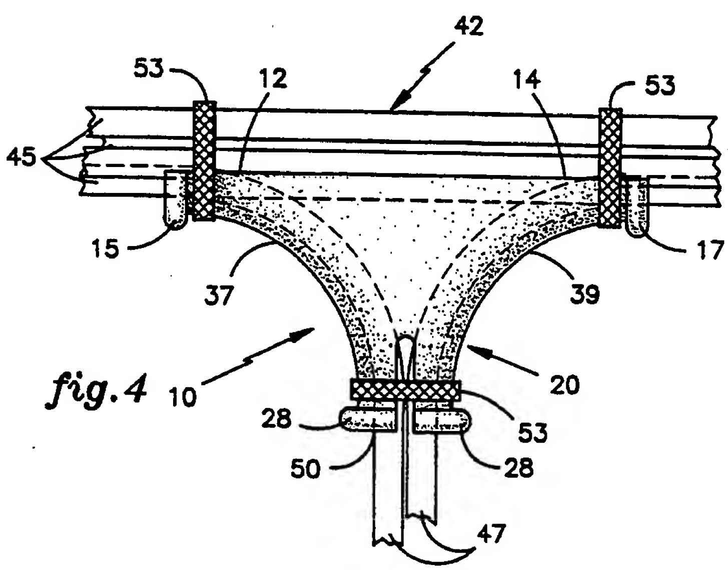


fig. 4

fig. 5

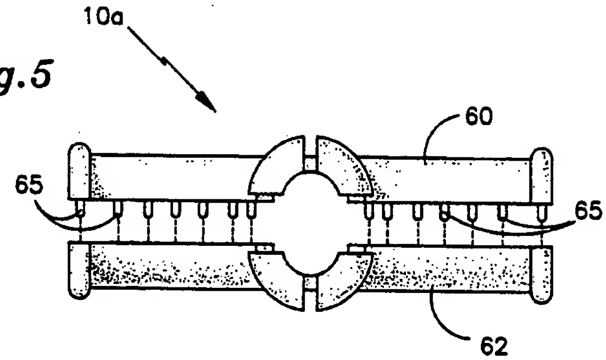


fig. 6

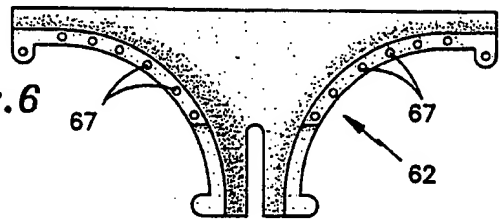
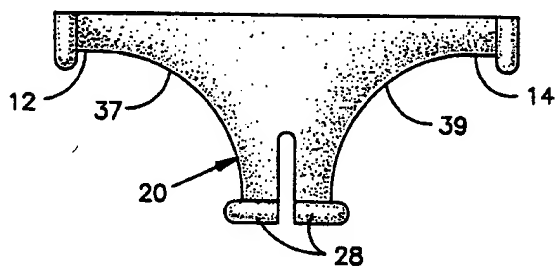


fig. 7



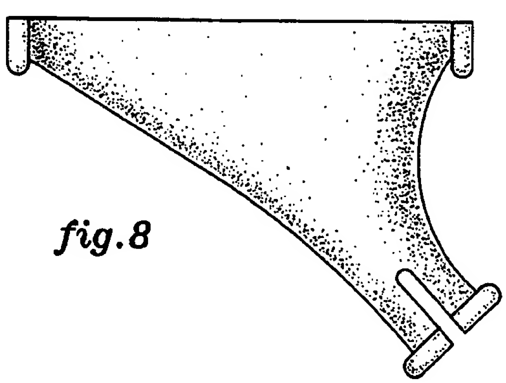


fig. 8

FIBER OPTIC CABLE HARNESS BREAK-OUT FITTING

TECHNICAL FIELD

The present invention relates to fiber optic cable, and more particularly, to a break-out fitting which supports and controls the bending radius of a fiber optic cable at a break-out location from a fiber optic cable harness.

BACKGROUND OF THE INVENTION

Cables which transmit information from one point to another by lo use of light energy and which utilize glass, plastic, or other signal carriers are typically referred to as fiber optic cables or optical data transmission cables. Fiber optic cables include optical fibers that typically are fabricated by drawing down a glass rod that contains a core region and a cladding region. The resulting drawn fibers provide a transmission path in the core region for light energy. When compared to metallic wire cables, fiber optic cables are superior in several respects.

For example, fiber optic cables have more possible signal channels because they utilize a wider band width than the electromagnetic band width used with metal conductors. Additionally, fiber optic cables typically have lower dB losses, and therefore have a much greater efficiency than metallic conductor systems.

However, metallic conductor systems have one great advantage over fiber optic systems in that metallic conductors are much stronger than fiber optic cables since most fiber optic cables are made of glass. If a fiber optic cable is subject to vibrations, severe bending, flexing, twisting or any other mechanical or physical force, the fiber may break, whereas in a system utilizing metallic conductors, the chances of breakage are much less. Additionally, when a fiber optic cable is bent, some of the energy may pass through the fiber cladding and be absorbed by the fiber coating. This may create a localized loss of light which is indicated by a reduction in the transmitted power. Different fiber and cable constructions have been found to provide various magnitudes of loss for a given fiber bend.

One example of when bending and possible breakage of fiber optic cables may occur is in a system having a bundle or harness containing a plurality of fiber optic cables. Along the length of the fiber optic cable harness, break-outs are provided wherein one or more of the fiber optic cables in the harness branch out for connection to a particular component within the system.

A fiber optic cable harness typically consists of multiple cable (termini-to-termini) segments secured in a bundle. The fiber optic cable harness is usually constructed by tying a bundle of fiber optic cables (segments) with spot ties (cable ties) made of a material such as MIL-T-43435 type II polyester lacing tape. In a harness having more than two connectors, groups of fiber optic cables are routed to each connector in break-outs from the main harness (trunk line) in a "T" pattern. Cable ties are used to hold the bundled cable segments together and to form the break-outs. The break-outs are formed by tying the trunk line on either side of the break-out location and bending the applicable segments away from the trunk line to form a branch. The branch is then secured into a bundle with additional cable ties.

During formation of a harness, a sharp bend may occur in individual cable segments at the break-out locations. This may occur due to excess tension being applied to one or more of the cables within the break-out bundle when an installer pulls on the branch. Excessive dB losses may occur at the location of a sharp bend. If the bend in a branch is excessive and the tension on the branch is large, individual fiber optic cables may crack or otherwise sever, resulting in a total loss of signal transmission.

SUMMARY OF THE INVENTION

Objects of the invention include the provision of a fiber optic cable harness break-out fitting which supports fiber optic cables at a break-out location on a fiber optic cable harness, and which controls the degree of bending of a fiber optic cable at the location of the break-out from the harness.

Another object of the present invention is to provide a fiber optic cable harness break-out fitting which minimizes dB losses in fiber optic cables at harness branch break-out locations.

According to the present invention, a fiber optic cable harness break-out fitting is provided with a pair of support legs for supporting contact with a fiber optic cable harness having a plurality of fiber optic cables, a take-off tube is positioned between the support legs, and the fitting is positioned on the harness such that the fiber optic cables that break-out from the fiber optic cable harness are received through a throat of the take-off tube, support surfaces are provided between each of the legs and the take-off tube, the surfaces having a controlled radius to control the degree of bend in the break-out fibers, the surfaces also providing for the transfer of tensile loads applied to the break-out fibers to the harness without allowing sharp bending of the break-out fibers.

In further accord with the present invention, the legs are mounted on the harness using tie down material, and the end of the take-off tube is slotted such that the break-out fibers exiting the tube are secured within the tube with tie down material, the slots providing the necessary flexibility to allow the take-off tube end to securely grip the break-out fibers.

In still further accord with the present invention, the angular relationship of the take-off tube to the legs is selected to provide the desired exit angle of the break-out fibers from the harness.

In further accord with the present invention, the fitting may be provided in two halves for installation in pre-existing fiber optic cable systems and for easy installation in new fiber optic cable systems.

The fiber optic cable harness break-out fitting of the present invention provides a significant improvement over the prior art by controlling the curvature radius of fiber optic cable segments that break-out from a fiber optic cable harness, thereby minimizing dB losses which may occur due to the existence of sharp bends in the fibers. Additionally, the harness provides for the transfer of tensile loads applied to the break-out fibers to the harness to further minimize the possibility of severance of one of the break-out fibers. The inside diameter of the fitting is selected to accommodate various size cables or cable bunches, and additionally, a cushioning material, such as silicon rubber tape, may be used within the fitting to cushion and allow secure gripping of smaller diameter branches which exit through the take-off tube. The take-off tube may be positioned at various angles with respect to the harness to allow the desired exit angle of a fiber or group of fibers from the harness.

Additionally, the fitting may be provided in two halves to allow retrofit of the fitting in a pre-existing fiber optic cable systems and ease of installation in new fiber optic cable installations.

The foregoing and other objects, features, and advantages of the present invention will become more apparent in light of the following detailed description of exemplary embodiments thereof, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top view of the fiber optic cable harness break-out fitting of the present invention;

FIG. **2** is a side view of the fitting of FIG. **1**;

FIG. **3** is an end view of the fitting of FIG. **1**;

FIG. **4** is a top view showing the fitting of FIG. **1** installed on a fiber optic cable harness;

FIG. **5** is a end view showing two halves of an alternative embodiment of the fitting of FIG. **1**;

FIG. **6** is top view showing the bottom half of the fitting of FIG. **5**;

FIG. **7** is a top view of a second alternative embodiment of the fitting of FIG. **1**;

FIG. **8** is a top view of a third alternative embodiment of the fitting of FIG. **1**;

BEST MODE FOR CARRYING OUT THE INVENTION

The fiber optic cable harness break-out fitting of the present invention is particularly well suited for minimizing dB losses in fiber optic cables at harness break-out locations. Additionally, the fitting of the present invention controls the degree of bending of fiber optic cables at break-out locations and minimizes the stress and strain on the fibers at the break-out locations.

Referring to FIG. **1** a top view of the fiber optic cable harness break-out fitting **10** (fitting) is shown. The fitting is preferably manufactured from a lightweight, strong, and durable material which provides flexibility and support for the fiber optic cables. Additionally, if the fitting will be subject to environmental conditions, it should be manufactured of a material which is resistant to damage caused by exposure to the environment. The preferred material for manufacture of the fitting is an ultra-violet light resistant nylon.

Referring to FIGS. **1, 2** and **3**, the fitting **10** comprises a pair of support legs **12, 14** for supporting contact with a fiber optic cable harness. Reinforcing members **15, 17** are mounted on the ends of the support legs for reinforcement of the support legs. Additionally, the reinforcing members are of a larger outside diameter then the support legs such that when a tie down material such as lacing tape is wrapped around the support legs and fiber optic cable harness, the reinforcing member retains the tie down material on the support legs and prevents the tie-down material from slipping off the support legs.

A take-off tube **20** is positioned between the support legs, the tube having a throat **22** for receiving fiber optic cables which break-out from the fiber optic cable harness (break-out fibers). A plurality of slots **24** are provided in the end of the take-off tube **20** to thereby allow the end of the take-off tube to easily deform to grip break-out fibers contained therein. Additionally, reinforcing members **28** are mounted on the end of the take-off tube to reinforce the take-off tube end and to retain tie down material on the take-off tube. When tie down material is securely applied around the end of the take-off tube, the end of the take-off tube deforms due to the slots **24** formed therein to securely grip any break-out fibers contained in the throat **22**.

The interior surfaces **35** of the fitting are smooth and provide an inside diameter to accommodate a break-out fiber or a bundle of break-out fibers. As described in greater detail hereinafter, the dimensions of the fitting **10** may be varied to accommodate various size break-out fibers and break-out fiber bundles. Supporting surfaces **37, 39** are provided between each of the support legs and the take-off tube. The curvature of the supporting surfaces is selected to control the radius of curvature of break-out fibers contained therein. Additionally, the supporting surfaces transfer tensile loads applied to a break-out fiber or bundle of break-out fibers to the harness without allowing sharp bending of individual fibers.

Referring to FIG. **4**, the operation of the fitting is best understood by example. In FIG. **4**, the fitting **10** is shown installed on a fiber optic cable harness **42** comprised of a plurality of fiber optic cables **45**. The fitting **10** is positioned with respect to the harness **42** such that the take-off tube **20** is located at a fiber break-out location. Break-out fibers **47** are fed through the throat **22** (FIG. **3**) of the take-off tube **20**, and the fitting **10** is slid down along the break-out fibers until the legs **12, 14** come in contact with the harness **42**. The fitting is selected such that the radius of curvature provided by the support surfaces **37, 39** provides the desired curvature to minimize dB losses in the break-out fibers **47**. Additionally, a fitting must be selected such that the interior surfaces **35** (FIG. **2**) and the inside diameter of the throat **22** (FIG. **3**) can accommodate the break-out fibers **47**. To provide improved gripping and strain relief of the break-out fibers, a cushioning material **50** such as silicon rubber tape may be positioned between the break-out fibers **47** and the take-off tube. Once the fitting is assembled on the harness, tie down material **53** is applied to the fitting adjacent to the legs **15, 17** and the end of the take-off tube **20** to secure the legs to the harness and the break-out fibers within the take-off tube. The reinforcing members **15, 17, 28** prevent the tie down material **53** from sliding off the fitting. The tie down material should be applied sufficiently tight to securely grip the fiber optic cables without damaging the fiber optic cables. A preferred tie down material is polyester lacing tape.

Although the fitting **10** is illustrated as being a single component structure in FIGS. **1** through **4**, it may be desirable to provide the fitting in two halves as illustrated in FIGS. **5** and **6**. Referring to FIGS. **5** and **6**, an upper half **60** of a fitting **10***a* is shown in spaced relation to a lower half **62** of the fitting **10***a*. Alignment tabs **65** may be provided on the upper half **60** to be received in recesses **67** in the lower half **62** for alignment of the upper half **60** to the lower half **62**. The tabs **65** and the recesses **67** may be formed such that the upper half is snap fit to the lower half so that when the tabs are received in the recesses, the upper half and the lower half are securely attached together. A fitting formed in two halves as illustrated in FIGS. **5** and **6** is particularly useful for installation in a pre-existing fiber optic cable system for providing controlled curvature of break-out fibers and also to prevent cracking of the break-out fibers. Additionally, a fitting provided in two halves as illustrated in FIGS. **5** and **6** may be useful in a new fiber optic cable installation where the feed through of a break-out fiber through the throat of the take-off tube

would be particularly difficult due to space requirements or the physical length of the break-out fiber. Although the fitting is shown divided in half by a horizontal section of the fitting illustrated in FIG. 3, it will be understood by those skilled in the art that the fitting may be halved by a vertical section of the fitting illustrated in FIG. 3.

The bending radius of a fiber at which dB losses occur may vary based on the construction of the fiber. Therefore, it may be desirable to provide fittings which have support surfaces **37**, **39** of varying radius. The fitting illustrated in FIG. 7 is an example of a fitting which provides a reduced radius of curvature for an optical fiber contained therein. Although not shown in FIG. 7, it also may be desirable to provide a fitting which has a smaller or larger internal surface **35** depending on the number of break-out fibers and the radius of the individual break-out fibers contained within the fitting.

It may also be desirable to provide fittings which provide various break-out angles with respect to the fiber optic cable harness. Break-out angle is defined as the angle at which break-out fibers leave the fiber optic cable harness. The break-out angle may vary due to the location of the various components interconnected by the fiber optic cables and the physical constraint of the area which is used to provide the fiber optic cable runs. The fittings illustrated in FIGS. **1** through **7** provide a 90° break-out angle of the break-out fibers with respect to the harness **42**. However, the alternative embodiment illustrated in FIG. **8** illustrates a 45° break-out angle of the break-out fibers **47** with respect to the harness. As will be understood by those skilled in the art, fittings which provide various break-out angles with respect to the harness may be provided as desired.

Although the invention has been described and illustrated with respect to exemplary embodiments thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto without departing from the spirit and scope of the present invention.

I claim:

1. A fiber optic cable harness break-out fitting for use at a fiber optic cable break-out location on a fiber optic cable harness containing a plurality of fiber optic cables, said fitting comprising:

- a pair of support legs for supporting contact with said harness;
- a take-off tube having a throat, said take-off tube being positioned between said support legs, said fitting being positioned with respect to said harness such that break-out fibers which exit said harness at said break-out location are received through said throat; and

- a pair of support surfaces between each of said legs and said take-off tube, said support surfaces having a controlled radius for controlling the degree of bend in said break-out fibers.

2. A fiber optic cable harness break-out fitting according to claim **1** further comprising reinforcing members mounted on the ends of said legs and said take-off tube.

3. A fiber optic cable harness break-out fitting according to claim **1** further comprising:

- slots formed in the end of said take-off tube; and
- tie-down means received over the end of said take-off tube in the region of said slots;
- said slots allowing the end of said take-off tube to flex and grip said break-out fibers contained therein in response to pressure applied by said tie-down means.

4. A fiber optic cable harness break-out fitting according to claim **3** further comprising reinforcing members mounted on the ends of said legs and said take-off tube, said take-off tube reinforcing member retaining said tie-down means on said take-off tube.

5. A fiber optic cable harness break-out fitting according to claim **4** further comprising tie-down means mounted on the ends of said legs adjacent to said reinforcing members, said tie-down means securing said fitting on said harness, said reinforcing means retaining said tie-down means on said legs.

6. A fiber optic cable harness break-out fitting according to claim **1** further comprising tie-down means mounted on the ends of said legs for securing said fitting on said harness.

7. A fiber optic cable harness break-out fitting according to claim **1** further comprising:

- a fitting first half, and
- a fitting second half.

8. A fiber optic cable harness break-out fitting according to claim **7** further comprising fastening means for attaching said first half and said second half together.

9. A fiber optic cable harness break-out fitting according to claim **7** further comprising alignment means for aligning said first half and said second half.

10. A fiber optic cable harness break-out fitting according to claim **5** further comprising:

- a fitting first half, and
- a fitting second half.

11. A fiber optic cable harness break-out fitting according to claim **10** further comprising fastening means for attaching said first half and said second half together.

12. A fiber optic cable harness break-out fitting according to claim **10** further comprising alignment means for aligning said first half and said second half.

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